Cusp upwelling and heating due to small-scale electric field fluctuations

Completed Technology Project (2018 - 2021)

Project Introduction

Science topic and objectives: Large neutral density enhancements associated with upwelling in the cusp region of the Earth's ionosphere are a consistent feature of F-region satellite measurements in the magnetic noon meridian and have received considerable attention. Various mechanisms have been proposed to explain the observations, but the most likely driver now appears to be Joule heating. In particular, small-scale structuring of the field-aligned currents (FAC) in the region has implied significantly enhanced Joule heating due to the associated small-scale electric field fluctuations that is therefore the major contributing factor responsible for the observed upwelling. Recent high-resolution modeling studies (Brinkman et al., JGR, 2016) have shown that features generally consistent with the observed neutral upwelling can be reproduced by the model when driven with reasonably-chosen electrodynamic forcing parameters. There have been few direct measurements, however, of the small-scale electrodynamic forcing and heating in the cusp, in spite of the critical role of the region in the coupling between the magnetosphere, ionosphere, and thermosphere at high latitudes. Specific goals for the experiment are 1) to obtain high-resolutions measurements of the fluctuating plasma drifts and estimates of the associated Joule heating over a horizontal region of several hundred kilometers within the cusp region, 2) to measure the horizontal and vertical neutral flow velocities over the same region, and 3) to use the measured plasma drifts to define the forcing for a high-resolution model and to compare the model horizontal and vertical neutral velocities with the observed neutral flow field in order to test our understanding of the coupling processes. Methodology We propose to launch a rocket from the Ny-Ålesund rocket range on Svalbard into the cusp region. The rocket will carry eight barium/strontium canisters to deploy a series of tracer clouds across the trajectory at F-region heights. The barium ionizes quickly when exposed to sunlight and provides a visible tracer of the ion flow. The barium clouds can be tracked for up to 30 minutes in these conditions and thus provide a Lagrangian measurement of the electric field fluctuations experienced by the plasma flow as it traverses the region. The strontium remains neutral and provides a visible tracer of the neutral flow field, including both the horizontal and vertical flow components. The in-situ data will be combined with radar data from the EISCAT Svalbard Radar (ESR) and ground-based optical data to estimate the small-scale fluctuating field contribution to the Joule heating across the cusp region. The proposed study is an international collaborative effort between Clemson and JAXA, the Japanese space agency, in which NASA will provide the launch vehicles and JAXA will provide the release canisters for the payload. Ground-based observations will be a shared effort between Clemson and participants from several other Japanese institutions. The high-resolution modeling will be carried out by the Aerospace Corporation. Data analysis will be a joint effort by all the investigators. The launches are proposed for November 2019 as part of the Grand Challenge Initiative campaign scheduled for that period from Andøya and Svalbard in Norway. Relevance Two of the overarching goals in the 2014 NASA Science Plan are to

Cusp upwelling and heating due to small-scale electric field fluctuations

Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Clemson University

Responsible Program:

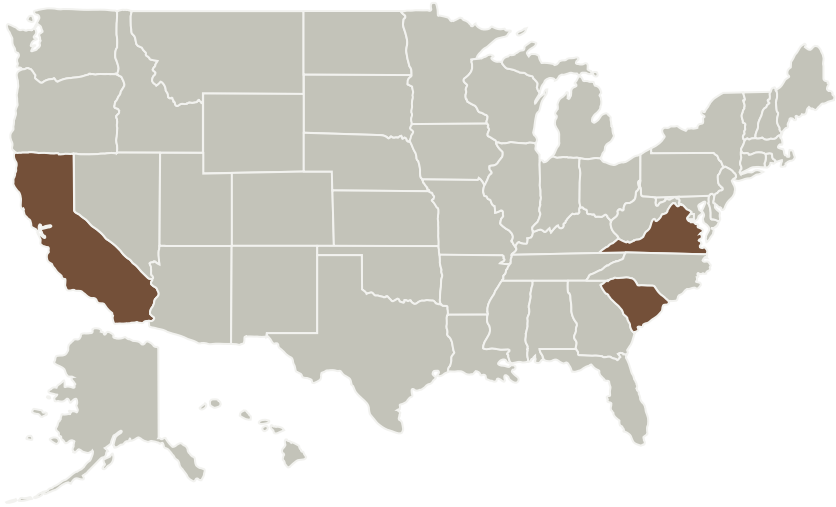
Heliophysics Technology and Instrument Development for Science

Cusp upwelling and heating due to small-scale electric field fluctuations

Completed Technology Project (2018 - 2021)

"Explore the physical processes in the space environment from the Sun to the Earth..." and to "Advance our understanding of the connections that link the Sun, the Earth, planetary space environments..." The interaction between the magnetosphere, ionosphere, and thermosphere in the Earth's cusp region is a critical link that connects the space environment to the Earth's atmosphere. Understanding the physics of the forcing in that region and the response of the neutral atmosphere is essential to our understanding of the coupling processes.

Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Miguel F Larsen

Co-Investigators:

Masa-yuki Yamamoto
Takumi Abe
Yoshihiro Kakinami
Douglas G Brinkman
Hiroto Habu
Shigeto Watanabe
Kristin Foster
Richard Walterscheid

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  - TX09.4 Vehicle Systems
    - TX09.4.5 Modeling and Simulation for EDL

Target Destination

The Sun

Cusp upwelling and heating due to small-scale electric field fluctuations

Completed Technology Project (2018 - 2021)

Organizations Performing Work	Role	Type	Location
Clemson University	Lead Organization	Academia	Clemson, South Carolina
Hokkaido Information University	Supporting Organization	Academia	
Japan Aerospace Exploration Agency(JAXA)	Supporting Organization	International	Sagamihara, Outside the United States, Japan
Kochi University of Technology	Supporting Organization	Academia	
National Institute of Technology, Tomakomai College	Supporting Organization	Academia	
The Aerospace Corporation	Supporting Organization	Industry	El Segundo, California

Primary U.S. Work Locations	
California	South Carolina
Virginia	